OBSERVATIONS UPON APPENDICITIS.

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THE relation of the vermiform appendix to certain inflammatory and suppurative conditions in the neighborhood of the cæcum has been the source of careful and extended study on the part of surgeons during the last few years, this being comparable, to a certain extent, to the interest manifested at the beginning of the present decade in the inflammatory and suppurative lesions of the Fallopian tubes, when careful study of these brought out the truths which relegated to the musty pathology of the past such indefinite terms as "parametritis" and "perimetritis," as well as "pelvic abscess," and substituted therefore salpingitis and pyosalpinx. The interest awakened in appendical lesions has led to a steadily increasing demand for definite knowledge of this, so far as known, useless organ and its diseases.

Exceptionally favorable opportunities have been afforded me of observing the disease appendicitis, in its different forms, both in hospital and private practice. With the hope of shedding some light upon what has been, until quite recently one of the darkest chapters in surgical pathology, as well as to offer such observations upon the management of the affection as have been suggested to me as the result of my own somewhat extensive experience in connection with it, the present work has been undertaken.

The subject matter will be presented in the following order: I. Anatomical Considerations. II. The Inflammatory Lesions of the Appendix. III. The Ætiology of Appendicitis. IV. The Clinical History of Acute Appendicitis. V. Special Types of Appendicitis. VI. Complications and Sequelæ of

Appendicitis. VII. The Morbid Anatomy of Appendicitis. VIII. The Diagnosis of Appendicitis. IX. The Prognosis of Appendicitis. X. The Treatment of Appendicitis. XI. An Analytical Study of 143 Cases of Appendicitis Coming Under the Author's Observation.

I. Anatomical Considerations.

The *caput cæcum coli* is the large blind pouch which represents the initial portion of the colon. It is usually defined as that portion of the latter which lies below the level of the ileo-cæcal valve. Its cavity measures somewhat more in the transverse than in the vertical diameter, being about two and a half inches in length by three inches in breadth. Its usual location is in the right iliac region lying upon the psoas magnus muscle, and its most dependent point or apex projects just beyond the inner edge of that muscle. This corresponds, externally, to a point slightly to the inner side of the middle of Poupart's ligament.

Occasionally the cæcum will be found external to the psoas, and lying upon the iliacus muscle in the right iliac fossa; or the bulk of the caput may lie upon the latter muscle, while the apex rests upon the psoas. Again, the cæcum may hang over the pelvic brim entirely clear of these structures, or be lodged within the cavity of the true pelvis. After the second month of intra-uterine life, the cæcum gradually recedes from the neighborhood of the umbilicus, which is the original position, and finally becomes fixed in the right iliac fossa. Instances of non-descent of the cæcum are not as infrequent as is generally supposed.

The condition of the cæcum will determine, to some extent, its relation to the surrounding parts. Thus, when distended, it may occupy the entire right iliac fossa, crowding the small intestine toward the median line. In the empty state, on the other hand, it is covered over by loops of the small intestine, or these may even reach to its outer side.

The direction of the cæcum is not in a straight line with the otherwise vertically placed ascending colon, but is somewhat obliquely placed from above downward and to the left.

The cæcum is maintained in its position in the right iliac fossa by the posterior reflection of the peritoneum, leaving a

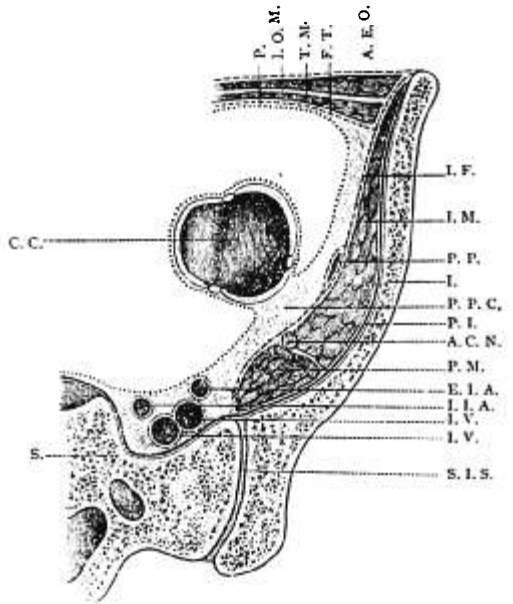

FIG. 1.—A transverse horizontal section through the pelvis at the level of the anterior superior spinous process of the ilium and sacro-vertebral angle.

Right Side.—Lower segment of the section. Adult male (after Tillaux).

A. E. O.—Aponeurosis of the external oblique muscle (broken line).
C. C.—Caput Coli.
I. F.—Iliac fascia broken line).
T. F.—Transversalis fascia (broken line).
E. I. A.—External iliac artery.
I. I. A.—Internal iliac artery.
I. M.—Iliacus muscle.
P. M.—Psoas magnus.
P. P.—Psoas parvus.
A. C. N.—Anterior crural nerve.
I.—Ilium.
P. I.—Periosteum of the ilium.
P.—Peritoneum (dotted line).
I. O. M.—Internal oblique muscle.
S.—Sacrum.
S. I. S.—Sacro-iliac symphysis.
T. M.—Transversalis muscle.
P. P. C.—Post-peritoneal connective tissue.
I. V.—Iliac veins.

variable portion of the posterior surface of this portion of the large intestine applied against the iliac fascia, with more or less

connective tissue the retro-cæcal co nnective tissue) between (Fig. 1). When a true mesocæcum exists this serves to connect the portion of the large intestine to the right iliac fossa.

The topographical anatomy of the cæcum, particularly with reference to its relations to the retro-cæcal and post-peritoneal connective tissue, as well as the large vessels in the neighborhood, is of importance in connection with the inflammatory lesions of and operations upon the vermiform appendix. If a transverse and horizontal section be made through the iliac fossa

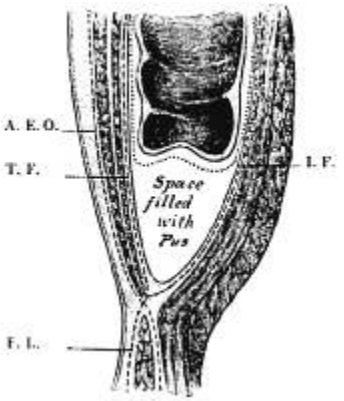

FIG. 2.—A. E. O.—Aponeurosis of the external oblique (broken line).
I. F.—Iliac fascia (broken line).
F. L.—Fascia lata (broken line).
Purulent collection shown crowding the peritoneum (dotted line) in an upward direction and limited below by the junction of the iliac fascia and the transversalis fascia at the crural arch.
T. F.—Transversalis fascia (after Tillaux).

upon a level with the anterior superior spinous process of the ilium and the sacro-vertebral angle, the average relative position of these parts in the adult will appear as shown in Figure 1.

The relation of the retro-cæcal and post-peritoneal connective tissue is of especial importance in those cases of appendical abscess in which the appendix is only partially covered by peritoneum. Under these circumstances infection of the struc-

tures above named gives rise to a true iliac phlegmon (Grisolle). The suppurative process develops beneath the peritoneum and crowds that structure in an upward direction, as well as anteriorly. There is thus formed in the iliac fossa a collection of purulent material situated sub-peritoneally, the boundaries of which are as follows: In front the transversalis fascia prevents its further progress in that direction, while the iliac fascia limits it posteriorly. The curved arch forms its boundary inferiorly.

If the pus is not evacuated early it may find its way into the general cavity of the peritoneum by a process of ulceration after crowding this structure in an upward direction, as shown by the dotted line (Fig. 2).

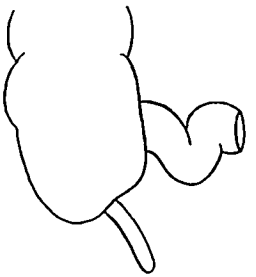

FIG. 3.

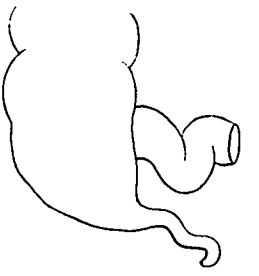

FIG. 4.

The passage of the external iliac artery and vein through the post-peritoneal connective tissue and forming the inner limit of the iliac fossa, offers an opportunity for the purulent collection to follow the sheath of these vessels and to make its appearance upon the anterior and inner aspect of the thigh. This occurs somewhat rarely in appendicitis, although one such case has come under my observation.

The appendix vermiformis cœci is an atrophied organ, the rudimentary remnant of the lengthened cæcum found in all mammalia except man, and some of the higher quadrumana. It is also found in the wombat. It is usually attached to what was originally the apex of the cæcum, close to the ileo-cæcal valve on the inner and posterior side of the bowel (Fig. 3). Excep-

tionally the fœtal type persists in which case the appendix may become a continuation of the long axis of the colon (Fig. 4). In another form the appendix appears between two bulging sacculi Fig. 5 ; or, in still another, the root of the appendix is posterior to the inferior angle of junction of the ileum with the cæcum (Treves), (Fig. 6).

Instances of non-descent of the cæcum result in a corresponding abnormal situation of the appendix; the latter has even been found lying to the left of the median line. Lennander mentions having observed in a dissection of a sixteen-year-old boy, the cæcum, together with an appendix nine inches long, lying against the spleen in the left hypochondriac region.[1]

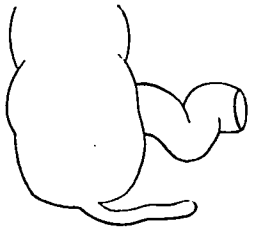

FIG. 5.

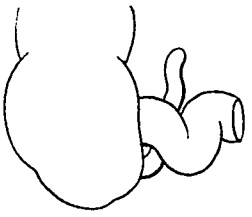

FIG. 6.

The length of the appendix varies from one to nine and a half inches; the average length is three and one-half inches. Its diameter is that of a goose quill. When a meso-appendix is present, this comes off from the left layer of the mesentery of the ileum, with which, together with the points of its attachment to the appendix, it forms two sides of a triangle; the third side of the triangle is formed by the free border of meso-appendix. In 200 cadavers examined by Ferguson, of Toronto,[2] the appendix in 100 cases was found to have a mesentery of its own. In the adult the mesentery extends from one-third to two-thirds of the appendix, and a fringe-like prolongation reaches from this point to the tip of the organ. This is composed of two peritoneal

[1] Sammlung klinischer Vorträge, No. 75, August, 1893.

[2] American Journal of the Medical Sciences, January, 1891.

layers, forming a fold between which considerable fat is sometimes deposited. This fold may sometimes enclose the iliac vessels as well. In the female the meso-appendix has a prolongation which is lost in the broad ligament; this is described by Clado as the appendiculo-ovarian ligament.[1]

The shape of the appendix varies greatly. It may be perfectly straight, particularly where the mesentery is very short or absent. The fact that the mesentery is frequently too short for the organ often gives the latter a curved shape. Shortening of more than one portion of the mesentery may give to the appendix a lateral curve, a succession of curves, or a cork-screw (periwinkle) shape.

The structure of the appendix is similar to that of the large intestine, but is not identical with it. From without inward are to be found the following layers:

(1) The peritoneal investment of the organ. The completeness with which this covers the organ varies greatly. Sometimes it is entirely covered, as a finger is covered by a glove; in other instances it is but partially covered. The latter condition was found in more than one-quarter of the observations upon the subject which have been recorded, including those of Maurin, who, in the examination of 112 subjects, found the appendix in the entire number completely surrounded by peritoneum. In the remaining three-fourths the appendix is free in the peritoneal cavity. In those instances in which it is only partially covered by peritoneum, the uncovered portion is in direct contact with the post-peritoneal connective tissue.

(2) The muscular layer. This consists of a few long non-striated muscular fibres, with which are mingled a varying amount of fibrous tissue, constituting the outer portion of the muscular layer. The inner part of the muscular coat forms the greater portion of the walls of the appendix. It consists mainly of fine fibrous tissue, arranged in a more or less circular manner. According to Austin Flint, circular muscular fibres do not exist.[2]

[1] Société de Biologie, January 30, 1892; Revue de Chirurgie, March, 1892.

[2] Text-book on Human Physiology, New York, 1888, p. 258.

(3) A relatively thick layer of connective tissue, with arterial openings and lymphatic depressions—the sub-mucosa.

(4) A mucous coat, having a thin muscularis mucosa, and lined with cylindrical epithelium. The mucosa contains tubular glands and closed follicles. According to Clado, glandular structure is also found in the walls of the appendix in small areas of adipose tissue. A duplicature of the cæcal mucous membrane near the orifice of the appendix, is sometimes described as a valve (Gerlach). This is not constant, and, even when present, forms but an incomplete valve.

The histological differences vary almost as much as the more readily recognized anatomical forms. The appendix is especially rich in lymphoid tissue, greatly resembling the tonsils in this respect. The proportion of lymphoid tissue may also vary greatly in different individuals, and at different parts of the same appendix. In some instances it is almost entirely absent. It is, as a rule, most abundant in children, although it is not by any means absent in the aged. Frequently the lymphoid tissue projects beyond the level of the mucous membrane, and encroaches upon the lumen of the organ. The mucous membrane itself is often built up of closely applied lymphoid cells, which are evidently undergoing the process of proliferation.[1]

The blood supply of the appendix is as follows: Anastomosis takes place between the superior mesenteric, ileo-colic, right colic, and middle colic arteries by means of arches, from which secondary loops are given off; from the latter an appendicular branch arises in connection with branches which supply the ileo-cæcal region. This appendicular branch, the essential nutrient artery of the organ, passes along the free edge of the mesentery, giving off branches on its way. In case the mesentery is absent, the artery passes beneath the peritoneal coat of the appendix. In exceptional cases the vessel may pass directly to the tip of the organ, giving off no branches until it is reflected in the sub-mucosa.

The lymphatics of the appendix pass into the appendicular

[1] A Contribution to the Pathology of the Vermiform Appendix. T. N. Kelynack, London, 1893.

lymphatic ganglion, which lies in the angle formed by the appendix and the cæcum (Clado). In the female, lymphatic channels pass along the appendiculo-ovarian ligament, between the folds of the peritoneum which form this structure, and establish communication between the appendix and the ovary.

The nerves of the appendix are derived from the superior mesenteric plexus of the sympathetic nervous system. Filaments from the branch which accompanies the ileo-colic artery pass to the organ. It is to be noted that the superior mesenteric plexus is finally largely distributed to the small intestine. This explains the general dissemination of the pain in the abdominal region in cases of appendicitis.

The location of the appendix, with relation to the cæcum, as well as to the general cavity and its contents, are important to the surgeon at the present time, in view of the fact that the removal of the organ (appendicectomy) has become an operation of frequent occurrence. Turner, of Moscow,[1] has made a careful study of eighty-three cadavers, in which the appendix lay freely in the abdominal cavity, with the following results:

In fifty-one, it hung down in the lesser pelvis.

In twenty, it passed transversely over the psoas muscle toward the sacral promontory.

In six, it lay freely upon the iliacus or upon the psoas.

In two, it passed upward upon the lateral surface of the descending colon.

In three, it lay in the meso-gastric region, with the commencement of the colon lying traversely.

In one, it lay in front of a right-sided sigmoid flexure.

In twenty-two cases in which the appendix lay behind the first portion of the colon, between this and the posterior abdominal wall, its relative position was as follows:

In four, it lay curled up behind the ileo-cæcal junction.

In five, it lay directly behind the cæcum.

In six, it passed intra-peritoneally along the posterior or postero-median surface of the colon.

[1] Chirurgichesky Vestnik, 1892, March and May; Centralblatt für Chirurgie, No. 41, 1892, p. 840.

In two, it passed in the same direction extra-peritoneally.

In four, it passed in the same direction, but only partly extra-peritoneally.

In one, the fundus of the cæcum turned upward and backward, the appendix lying behind it.

Professor J. D. Bryant, of New York,[1] in a study of the direction of extent, location and direction of the appendix, based upon 144 dissections, gives the following tabulated statement. The influence of sex in the arrangement was considered as based upon eighty-six male and forty female cadavers. In eighteen of the 144 cases the sex was not stated.

Direction of the Appendix.	Male.	Female.	Not Stated.	Total.
Inward	20	11	3	34
Behind the cæcum	18	10	4	32
Downward and inward	16	7	5	28
Into the true pelvis	14	3	4	21
Downward	5	0	0	5
Upward and inward	4	5	0	9
Upward and backward	3	0	0	3
Upward and outward	2	0	0	2
Outward	1	1	0	2
Upward along the inner side of the colon to liver	1	0	0	1
Upward outside of ascending colon and cæcum	1	3	0	4
Curled below the cæcum	1	0	0	1
Downward and outward	0	0	1	1
Upward and back of the cæcum and colon	0	0	1	1
Totals	86	40	18	144

Dr. A. T. Bristow, one of my assistants at St. Mary's Hospital, has suggested a simple method of classifying the position and direction of the appendix. It consists in locating a central point in the right iliac fossa, and from this as a centre drawing lines radiating in the different directions that the appendix assumes, and representing its attachment to the cæcum by the above-mentioned central point. The radiating lines are indicated by numbers. I have modified this method by substituting the ini-

[1] Annals of Surgery, February, 1893, page 164.

tial letters of the points of the compass for the numbers. A reference to the accompanying figure, will show the application of the method. The line W. E. is drawn transversely to the median line of the body, and tangentically to the base of the cæcum when in its normal situation. From the point where the cæcum touches this line, the appendix may take any one of eight different directions indicated respectively by the radiating lines W., N. W., N., N. E., E., S. E., S., S. W. (Fig. 7).

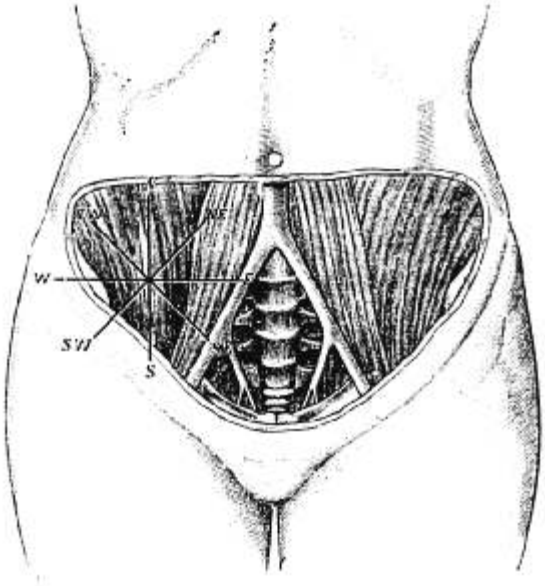

FIG. 7.

Appendices arising from colons abnormally placed form a class by themselves.

The appendix may pass either above or below the transverse line W. E. When above, it may take any one of the three general directions indicated by N. W., N. and N. E. If below the transverse line, it may in like manner take any one of the downward directions indicated by the lines S. W., S. or S. E. It

may also run directly outward in the W. direction, or directly inward in the E. direction. When it takes the N. line it will usually lie behind the colon, although it may exceptionally take this direction anterior to the ascending colon. When the appendix takes the general direction E., if sufficiently long, it may cross both iliac vessels and appear in the left iliac fossa, where its presence may give rise to left-sided appendicitis. If the organ presents a decided inclination toward the anterior or posterior abdominal wall, in either of these positions, the initial V (ventral) in the case of the former, or D (dorsal) in the case of the latter, may be added.

When the direction of the appendix is S. E., it very frequently passes across the vessels into the true pelvis. This point should be borne in mind when a differential diagnosis is to be made between appendicitis occurring in the female and inflammatory conditions of the pelvic organs.

Adopting this method of classification and study, Dr. Bristow[1] reports the following as the position and direction of forty appendices in dissecting-room subjects:

CLASS A. COLON NORMALLY PLACED.

(1) Appendix above the transverse line:
Line N. W., 1; line N., 9; line N. E., 0; total 10.
(2) Appendix parallel with the transverse line:
Line W., 0; line E., 4; total, 4.
(3) Appendix below the transverse line:
Line S. W., 2; line S., 6; not into pelvis, 1; into pelvis, 15; total, 24.
Total number in Class A., 38.

Of these, one appendix, proceeding in the direction E., reached across to the left side, just beneath the linea semi-lunaris; one in the direction of N. just touched the liver.

CLASS B. COLON ABNORMALLY PLACED.

In the pelvis, 1; in the scrotum, 1. In each case the appendix lay behind the displaced colon.

[1] Meeting of the Brooklyn Surgical Society, April 6, 1893.

II. The Inflammatory Lesions of the Appendix.

Definition and Classification.—The inflammatory lesions of the appendix were formerly comprehended under the terms typhlitis, peri-typhlitis and para-typhlitis. Typhlitis was defined as an inflammation of the cæcum itself (Albers); the second indicated an inflammation of the parts immediately surrounding the cæcum (Goldbeck); while the third was used to designate an inflammation of the post-peritoneal connective tissue of the cæcum (Oppolzer). At the present time, thanks to the writings of Fitz, of Boston, and of McBurney, of New York, these diseases are very generally known to be due to lesions occurring primarily in the appendix, and extending thence to the peritoneal investment of the organ or to the post-peritoneal tissue in the neighborhood.

To Grisolle is due the credit of having persistently opposed the teachings of Albers regarding the pathology of these affections. The views of the latter have found their way, however, into almost every text-book in which the subject is discussed since 1839, while the true pathology of the disease, although ably set forth by Grisolle[1] in the same year, was disregarded for more than half a century until brought to light and verified by the American observers just mentioned.

Grisolle contended that simple inflammation of the mucous membrane of the cæcum could scarcely give rise to the grave consequences involved in the phlegmonous inflammatory conditions as they occur in the right iliac fossa, since dysenteric and other well-recognized forms of ulceration of the same structures show no tendency to extend into the neighboring connective tissue. On the other hand, inflammation of the vermiform appendix of the cæcum, followed by perforation, phlegmonous inflammation, and abscess in the right iliac fossa, explained in a rational manner the course of events as they actually took place; moreover, the explanation was verified by investigations carried out in the dead-house. The views of Albers were purely artificial and speculative, while those of Grisolle were based upon accurate anatomico-pathological researches.

[1] Tumeurs phlegmoneuses des fosses iliaques, Archives de Medecine, 1839.

The term "typhlo-enteritis," introduced by Burne, is equally objectionable as being misleading; this writer suggested that the term be applied to inflammation of the cæcum and of the appendix as well.

The term "iliac phlegmon" simply implies one of the sequences of the disease, and in the light of our present knowledge, should also be rejected.

The possible appearance, though as a rare affection, of a genuine "stercoral typhlitis" is still maintained by Lennander. The occurrence of fæcal stasis giving rise to an inflammatory paresis of the cæcum, thus increasing the stagnation of the intestinal contents, and this in turn increasing the resistance offered by the inflammatory conditions, are supposed to be the pathological sequences involved in its occurrence. This view is opposed by Professor Sahle.[1] Unfortunately, abscesses which might be supposed to have their origin in this manner, are simply evacuated, the appendix, in all probability, the cause of the trouble, being entirely disregarded. A case of intestinal obstruction observed by Lennander[2] indicates the possibility of its occurrence, but the question must still be considered *sub judice*.

In view of the prominent part that the appendix takes in these affections, if, indeed, it be not the structure exclusively involved in the primary lesions, it is deemed advisable to discard the terms "typhlitis, peri-typhlitis and para-typhlitis," as well as "typhlo-enteritis" altogether, as applied to the conditions usually met with, and to substitute for all of these the term "appendicitis" when speaking of the disease in a general way. Endo-appendicitis is the so-called catarrhal form, while the name parenchymatous appendicitis (parietal appendicitis) is applied to the variety of the disease usually developed from this by an extension of the inflammation to the sub-mucous connective tissue, and thence to the muscular layers. Ulcerative, gangrenous, and suppurative forms also occur (see pathological anatomy).

For clinical purposes it is convenient to divide the disease into the following-named stages, but the fact is always to be

[1] Korresp. Blatt für Schweitzer Aerzte, 1892, s. 593–611.

[2] Sammlung klinischer Vorträge, No. 75, 1893.

borne in mind that these stages may merge imperceptibly into one another, and that one or more stages may be absent altogether.

First Stage.—*Endoappendicitis.*—In this stage a more or less intense inflammation of the mucous membrane and sub-mucosa occurs. The attack may advance no further than this stage. It corresponds to the stage of "appendicular colic," as described by Talamon,[1] and covers a period of about twenty-four hours. Talamon states that this stage is ordinarily prolonged from two to three days, and that it covers the period of the engagement of a stercoral calculus in the appendix. This is probably an error. I have more than once performed appendicectomy during the first forty-eight hours of the existence of the disease, and have never found evidences of this engagement of a coprolith at the cæcal orifice of the appendix. On the contrary I have frequently failed to find even soft fæcal masses within the appendix. Usually the most indubitable evidences of endo-appendicitis, parietal appendicitis, or periappendicitis, or all three, are found even at this early period.

While it is true that this stage may only represent a so-called catarrhal inflammation, many physicians make the error of considering the condition as one of slight importance. In addition to the fact that the disease may run through all four stages within three days, and the first three stages within forty-eight hours, there are especially dangerous conditions that may supervene, or accidents which may occur, even when the inflammation seems to be limited to the mucosa and sub-mucosa.

The first of these dangers is the occurrence of constriction of some portion of the tube by the swelling of the mucous membrane, and of the sub-mucous connective tissue. The parts first involved in the inflammation advance the most rapidly to the stage of engorgement and infiltration. As a result of this a constriction of the lumen of the appendix occurs, at one or more points, the effect of which is to imprison within what is now practically a closed cavity, the mucus resulting from the hypersecretion of the inflamed mucous membrane, together with what-

[1] Appendicite et Perityphlite par Ch. Talamon, Paris, 1892.

ever fæcal matter there happens to be within the tube. As a further complication of this stage the pressure effects of the infiltrated connective tissue spaces of the sub-mucosa from without, and the accumulated secretion from within, should not be lost sight of. The appendix, like other vestigial structures in the animal economy which have ceased to functionate as a result of evolutionary changes, possesses but slight vital resistance. Interference with its blood supply to an extent which, in other organs would be of but minor importance, here produces the most disastrous consequences. These include necrosis of the mucosa, which invites rapid bacterial infection of the walls of the appendix, ulcerative destruction of a circumscribed character, and this in its turn leads to a perforation from the presence of accumulated and retained mucus and muco-pus; finally gangrene of a portion or of the whole of the organ may develop.

Gangrenous inflammation may likewise result from a direct occlusion of the nutrient vessels of the body of the organ. As a result of an infection of the sub-mucosa an endarteritis or phlebitis, having their origin from the paravascular connective tissue spaces, occurs; the endothelial lining of the vessel then becomes roughened and thickened, and a stasis thrombosis follows. Certain anatomical peculiarities of the vessels themselves may favor the production of the gangrenous condition. For instance, it may happen that but a single nutrient artery exists, and that this may not give off any branches before reaching the tip of the appendix, being there reflected upon itself in the sub-mucosa. This condition was found to exist in one of my cases: a stasis thrombosis of septic origin occupied the lumen of the vessel at a point about one-third of the distance which the vessel traversed from the tip to the base of the organ. Endoappendicitis, engorgement of the vessels of the mucosa, capillary stasis, necro-biological changes in the mucosa, infection of the sub-mucosa, endarteritis and thrombosis were all found to have taken place within ten hours following the first symptom of the disease. Under these circumstances the primary inflammatory lesion occurs in the peripheral portion of the organ, and the occlusion of the vessel takes place at this point; following this a gan-

grenous condition will supervene in the portion of the appendix lying between the point of occlusion and the base, since there is no other blood supply save through the reflected trunk.

SECOND STAGE.—*Parietal Appendicitis.*—This stage is characterized by an inflammatory process, whose seat is in the interstitial or intermuscular structure of the body of the appendix. It is analogous to the corporeal metritis of the gynæcologists. It presents in its simplest form an ordinary serous inflammation, with engorgement of the vessels, and the presence of an exudate in the perivascular spaces. The infection may take place through the sub-mucosa or through the lymphatic channels leading directly from the mucous membrane. As a result of circulatory disturbances (endarteritis obliterans), one or more circumscribed points of ulcerative action may develop, involving both the mucous lining and the peritoneal investment, and leading to perforation. Or from interstitial pressure strangulation may occur in addition, and complete gangrene of the organ may follow.

Again, suppurative inflammation may occur in parietal appendicitis in the form of a rapidly spreading phlegmonous inflammatory process or several circumscribed points of suppuration the result of septic embolism. In this manner several foci of suppuration may make their appearance simultaneously.

THIRD STAGE.—*Peri-appendicitis.*—A further step in the pathological process involved in this disease consists of an infection and consequent involvement in the inflammatory process of the peritoneum which invests the appendix. The limitation of the peritoneal infection to that portion of the serous membrane which covers in the organ, with the occurrence of adhesions between the appendix and the serous surfaces immediately adjacent, mark the boundaries of this stage.

FOURTH STAGE.—*Para-appendicitis.*—In this stage the most serious consequences, arising from the presence of the disease, manifest themselves, although the dangers of the affection, as we have already seen, are by no means limited to this period. Following the formation of adhesions, infection of the fibrino-plastic exudate constituting these may take place either through the lymph channels of the appendix from perforation of the walls of

the latter and infection from the walls of the tube, or by direct infection from one or more of the foci of suppuration in the walls of the appendix. Thus it may happen that, upon opening into an appendicular sero-purulent collection or abscess, the result of a para-appendicitis, the appendix may be found either perforated or intact.

Para-appendicular abscess, arising from suppurative inflammation in the retro-peritoneal connective tissue with which the uncovered portion of the appendix comes in contact, in cases where the organ is extra-peritoneally situated in whole or in part, also occurs in this stage of the disease.

Infection of the retro-peritoneal connective tissue, or of the mass of adhesions, or of both, in either of the ways above described, results in the occurrence of a suppurative inflammation within these. The suppuration may be limited to the adhesions themselves, and remain distinctly circumscribed, or it may assume a spreading, phlegmonous character here, as well as in the retro-peritoneal connective tissue. In the first instance, the formation of a sero-purulent collection; in the second, an abscess occurs with limiting walls, beyond which the peritoneal surfaces remain comparatively healthy (the "iliac phlegmon" of the older writers). With the formation of a spreading or phlegmonous inflammation the case is different. Here one of three things may result: First, a diffused peritonitis may take place, from septic infection, though the serous effusion following this need not necessarily become purulent. Second, a general suppurative peritonitis may occur from pyogenetic infection of the serous effusion. The *bacterium commune coli*, which, under certain circumstances, assumes pathogenetic properties and may even become exceedingly virulent, finds its way to the seat of the effusion through the usual channels of infection. In all probability this micro-organism is itself the infective agent which produces both the appendicitis and the peritonitis. The serum at once becomes a culture medium for the bacterium, and as a result of this a rapidly progressive suppurative process develops, followed by general septic infection. Third, secondary, encysted intra-peritoneal foci of suppuration may form. Here a serous effusion may

occur beyond the limits of the original para-appendicitis, from localized peritonitis, due to indirect or lymphatic infection. The serum subsequently undergoes suppurative changes.

It should be stated, in passing, that the occurrence of septic peritonitis, either diffused non-suppurative, diffused suppurative or intra-peritoneal and encysted, is not necessarily limited to the fourth stage, or deferred till the formation of adhesions. From the first appearance of an endoappendicitis, channels of infection are opened which may lead to the occurrence of any one, or of all of the forms of septic peritonitis, without the occurrence of perforation, formation of adhesions or rupture of a sero-purulent collection or an abscess cavity.

The term "para-appendicitis" is sometimes employed to designate suppurative inflammation of the connective tissue adjacent to that portion of the appendix which is not covered with peritoneum, when this anatomical condition exists. Inasmuch as this condition is exceptional, while suppurative inflammation of the connective tissue and inflammatory new formation about the appendix is of very common occurrence, the term is here employed as a convenient one to designate both conditions. In the case of the connective tissue, ordinary pus is produced, while in the case of the mass of adhesions, an intra-peritoneal sero-purulent collection results.

Circumscribed inflammatory processes within the peritoneum do not, as a rule, show the same tendency to spread from the very beginning as do those occurring extra-peritoneally. In the case of the latter the entire plane of connective tissue of the dorso-lumbar region may become rapidly infected. As a result of this lumbar phlegmon, subphrenic abscess and para-nephritic abscess arise from lesions of the appendix.

In pursuing the study of the clinical history of the disease, it becomes at once apparent that it presents itself with different degrees of severity, from the acute form on the one hand, the different stages of which have just been discussed (the hyperacute form of Talamon), to the subacute form on the other, with its slight febrile action and moderate abdominal pain and tenderness. In addition to these, there are different phases of the disease to

be noted clinically. These consist of the recurrent form, and of the chronic form, which in its turn may lead to the relapsing variety.

The Ætiology of Appendicitis.

The ætiology of inflammatory suppurative conditions in the neighborhood of the right iliac fossa was supposed in former times to involve the presence within the appendix vermiformis, of cherry-stones, grape-seeds, lemon- and orange-pits, date-stones fish-bones, pins, etc. This idea was so firmly fixed in both lay and professional minds that children were carefully watched while eating fruit to prevent them from swallowing a stone or seed, which, it was believed, would lodge in this "death trap," as it was popularly called, and produce what was at that time considered an almost necessarily fatal malady.

This belief seems to have been based upon evidence which is deemed insufficient by scientific men of the present day, although it is not to be denied that traumatic appendicitis may occur. The following instance reported by M. Mustivier, as far back as 1759, the account of which is borrowed from Talamon, may have served, like the pathology of the disease as set forth in Albers, as a basis for the writings of subsequent authorities:

A man, forty-five years old, was admitted to the Hospital St. André de Bordeaux, suffering from a fluctuating tumor in the umbilical region to the right of the median line. The tumor upon being opened discharged a pint of pus. A fatal termination took place, and at the autopsy a pin was found, encrusted with earthy matter, which had served as the starting point of the disease by perforating the appendix vermiformis cæci.

There can be no question in this instance of the origin of the condition; but this case was not one of appendicitis, as we now view it. A similar condition might have followed the passage of the pin through any portion of the intestinal wall. Even the presence of the "earthy matter" need not necessarily have prevented the point of the pin from perforating the walls of the appendix.

The belief that the disease is frequently due to the engage-

ment of foreign bodies in the cavity of the organ, is based to a large extent upon purely speculative or imaginary conditions, or erroneous observations. In an exceptionally large experience in the operative treatment of this disease, in but two instances was any body found other than soft fæcal masses, which could be construed as being in any sense "foreign." One of these two was a true enterolith, oval in shape, and made up of calcareous salts, arranged in concentric layers (Fig. 8); the other was a gall-stone. The exceptionally rare character of the foreign body in this latter instance, will perhaps warrant a detailed account of the case. It is further interesting from the fact that it approaches nearer than any case with which I have been brought in contact, to the cases of so-called appendicular colic that Talamon has

Fig. 8.

described; these he employs as a basis upon which to build up the theory that hardened fæcal matter forced into the "musculo-membranous tube" is a prominent cause of appendicitis.

Case LXI.—The patient, an upholsterer by trade, was brought into St. Mary's Hospital on August 15, 1891, with the following history: On July 8, while hanging shades, he swallowed a small nail, such as is used for fastening the shade to the roller. Upon the same day he suffered from an attack of sharp pain in the right hypochondriac and epigastric region, which required full doses of opium to allay. This was thought by his medical attendant to be in some manner connected with the presence of the nail. This attack subsided, and ten days later another accession of violent abdominal pain occurred, which finally settled in the right iliac fossa. Upon his admission a tumor was found in the right iliac fossa. A laparotomy revealed an abscess cavity, containing six ounces of pus, during the evacuation of which a gall-stone, the size of the tip of the little

finger escaped. Further exploration revealed the fact that an appendicitis existed, the cause of which was evidently an attempt on the part of the gall-stone to enter the cavity of the appendix. This was shown by the sloughing away of the appendix from the cæcum at the point of its attachment. A ragged hole in the cæcum, with gangrenous margins, occupied the site of the base of the appendix, which could be felt as a hard, rounded, elongated, rope-like body, lying in a mass of adhesions in the southeast position.

In this case it is evident that the gall-stone was the cause of the appendicitis. It had lodged directly at the appendicular orifice. Its roughened exterior had probably produced an abrasion of the epithelial lining of the cæcum, and necrosis of the mucous membrane had taken place. This in turn was followed by an infection of the sub-mucosa. The occurrence of gangrene, causing the separation of the appendix from the cæcum, may be explained either by the persistent pressure of the gall-stone or by the accidental occurrence of thrombo-stasis, due to occlusion of the nutrient artery. The presence or absence of a mesentery for the appendix could not be ascertained.

In all probability the notion that cherry-stones, lemon- and orange-pits or date-stones are largely responsible for the occurrence of the disease is based upon the fact that little masses of fæcal matter, which have been moulded into shapes accurately representing these bodies in size and shape are found during the evacuation and irrigation of an appendicular abscess. It has happened more than once during an operation of this character at my hospital clinic that one or another of the bystanders has exclaimed, as the little mass of fæcal matter came into view, "a lemon-pit!" or "a date-stone!" so strong a resemblance was there between these masses and the bodies mentioned. In every instance, however, the fact that they were, with the above-mentioned exceptions, made up of molded fæcal matter was demonstrated by simply flattening them out between the thumb and finger.[1]

[1] The possibility of the production of the disease by foreign bodies is not denied; the statement is simply made that, as a clinical fact, in my experience it is of rare occurrence.

Beyond the little masses of fæcal matter which become imprisoned in the cavity of the appendix by the occurrence of constriction, either at the point of communication with the cæcum or at some other portion of the tube, nothing in the shape of a foreign body, other than those above-mentioned, has been found in my experience to account for the conditions present. The ease with which fæcal matter may maintain its position in the cavity of the appendix may be easily understood when two facts in the anatomy of the organ are borne in mind. These are, first, the fact that it normally occupies a dependent position in the large majority of cases; hence, gravity alone will aid the passage of fæcal matter into its interior, and also favor its retention there. Second, the absence of well-marked circular muscular fibres gives rise necessarily to a very feeble expulsive power. Hence, it may be said that the appendix vermiformis does not have that inherent power of emptying itself which other hollow organs, supplied with longitudinal and circular involuntary muscular fibres, combined in proper proportions, possess. In addition, anatomical studies and clinical experience (examinations made of healthy appendices during laparotomies) unite to support the assertion that fæcal matter is found in a considerable number of appendices in individuals who had never suffered from the symptoms of appendicitis. The mere presence of masses of fæcal matter, therefore, cannot be looked upon as necessarily producing the disease, even though these become more or less hardened by inspissation. This hardening process takes place after their imprisonment, and is due to absorption of the watery elements after the escape of the fæcal matter itself is cut off. In this condition they may, by their presence, produce in an already inflamed and partially devitalized organ, ulcerative changes, or even extensive gangrene, by still further interfering with the normal circulation. That they do not necessarily give rise to the disastrous perforation which is so frequently a marked feature of the disease is shown by the fact that they are not always present when this accident occurs. When they are present they are rarely found at the point of ulceration, but are located, in the great majority of cases, either above or below the

site of the perforation. Moreover, cases are observed in which the entire outer structure of the appendix has sloughed away as a result of a violent inflammatory process, leaving the mucous membrane as an intact blind sac with fæcal matter in its interior. The following case, occurring in my hospital service, will illustrate this condition:

CASE LVII.—H. T., aged eighteen, male, was admitted to the Methodist Episcopal Hospital with the history of having been attacked seven days previously with the usual symptoms of appendicitis. General peritonitis was present and the patient's condition was very unpromising. The usual right-sided laparotomy revealed the remains of the appendix in the shape of a worm-like tube, consisting exclusively of the mucous lining of the organ. This was not perforated, although at a point midway between its tip and the place of its attachment to the large intestine its lumen was occupied by a rather hard fæcal concretion (Fig. 9). The walls of the organ had sloughed completely away. The cavity of the peritoneum contained a large amount of sero-purulent material.

FIG. 9.—The intact mucous lining of an appendix, the outer walls having sloughedaway, showing a coprolith in position.

How much the presence of fæcal matter, independent of its mechanical effects, may influence the origin of the inflammation is yet to be determined. The fact that fæcal matter of itself does not necessarily give rise to the disease is, to my mind, sufficiently proven.

In all probability it will be found that the inflammation has its origin in noxious agents which are conveyed to the interior of the organ in the fæcal matter when the latter is present. These agents are not always present in fæcal matter, and may find their way into the tube without the aid of the latter. The micro-organisms having their natural habitat within the colon, notably the variety known as the *bacterium commune coli*, may assume a pathogenic rôle when they escape from the colon. In

one of my cases a pure culture of this bacterium was obtained from a layer of plastic lymph which glued the inflamed appendix to the cæcum. The mucous membrane of the organ, however, was not involved in the inflammatory process, and sections of its walls failed to reveal the presence of the micro-organism.

Pure cultures of the *bacterium commune coli* can be obtained from the peritoneal surface of an inflamed appendix, which has not undergone perforation, as well as from the walls of the organ and the interior of its mucous canal. This has been accomplished by one of my assistants, Dr. A. T. Bristow, who has also obtained for me pure cultures from the contents of an appendicular abscess, and from both isolated and non-encysted intra-peritoneal collections of fluid. These observations were made upon cases operated upon by myself, taken at random from my hospital service, and were commenced in September, 1892.[1]

The pathogenic power of the *bacterium commune coli* derived from both the contents of the dilated cavity of an appendix the seat of a rapidly developed inflammation, as well as the comparatively unaltered portion of the organ, is illustrated by the following case:

CASE 142.—M. S., aged twenty-seven, was attacked with the usual symptoms of appendicitis. I removed the appendix thirty-two hours after the commencement of the attack. The organ was the seat of a so-called cystic dilatation, the distal two-thirds of the organ, which was four inches in length, being distended by a stenosis at this point, while the proximal portion was but slightly enlarged beyond the normal. In removing the appendix the section was made between two ligatures. The specimen, upon examination by Dr. Wilson, at the Hoagland Laboratory, gave the following result:

Cultures made from the proximal portion of the organ developed the *bacterium commune coli* in pure culture. Cultures made from the distal, or dilated portion likewise developed the same bacterium alone. The cultures were plated and bouillon cultures made from isolated colonies. The bouillon cultures, when twenty-four hours old, were injected into the peritoneal cavity of guinea pigs. The injections caused death in twenty-four hours. The bacillus was recovered

[1] The New York Medical Journal, Vol. LVIII, October 14, 1893, page 434.

in pure culture from the exudate in the peritoneal cavity. Very few organisms were found in the organs, and death was due rather to toxæmia than to peritonitis.

No foreign body or fæcal matter was found in the appendix.

Evidence is constantly accumulating which shows that the common bacillus of the colon is not always an innocent micro-organism. It may pass the barrier of the intestinal mucosa (although under proper conditions it may also set up an active desquamative process here), and penetrate into the general circulation, producing disturbances in a wide variety of organs and virulent toxic effects upon the system at large. It has been found by Wyss in a case of enlarged spleen; by Larulle, Roux, Rodet and A. Fränkel in suppurative peritonitis; by Tavel in a hematoma following thyroidectomy; by Gilbert, Girode, Naunyn and others in diseases of the biliary passages; Rodet, Veillon, Jayle, Stern and A. Fränkel found it in abscess of the liver; Levy demonstrated its presence in lymphangitis of the arm; and Chiari found it in a case of septic emphysema in a diabetic patient. Stern discovered it in a case of general pyemic infection, with suppurative meningitis. Lasage and Maxime Macaigne have found it in the stage of reaction of cholera. Its existence has been shown in cholera infantum, dysentery, broncho-pneumonia, endocarditis, meningitis, nephritis and cystitis by the labors of Henkemaus.[1] Welch noted its existence in cases of peritonitis consecutive to an intestinal lesion without perforation.[2] This latter observer believes that the micro-organism does not necessarily possess nor assume pathogenetic characteristics so long as it is brought in contact only with sound mucosa, but that following almost any lesion of the intestine it becomes migratory. My own experience accords with the observations of Veillon and Jayle, *i. e.*, that Escherich's *bacterium commune coli* can produce not only inflammatory lesions, but suppuration as well.[3] Roswell Park has found this micro-organism in cases

[1] Zur Kentniss der pathogen Wirkung des Colon-bacillus beim Menschen; R. Stern (Breslau); Deutsche Medicinische Wochenschrift, No. 26, 1893.

[2] American Journal of the Medical Sciences, November, 1891.

[3] La Sem. Med., 1891; Centralblatt für Bacteriologie, Band IX.

of the acute perforative, of the gangrenous and of the recurrent varieties of appendicitis.[1]

The experiments of Ekehorn[2] seem to establish with reasonable certainty an ætiological relation between the presence of the *bacterium commune coli* and appendicitis. This writer details a number of experiments upon lower animals with cultures of the micro-organisms derived from cases of the disease, in which not only was their pathogenetic rôle demonstrated, but some of the experiments tended to show that, in comparatively mild forms of the disease (recurrent and chronic relapsing cases), the virulency of the bacterium was not as great as shown by its effects upon the lower animals following inoculation, as cultures derived from acute and rapidly progressive instances of the disease.

Dr. Eugene Hodenpyl, of New York, has recently made a very careful study of the ætiological relations of bacteria to appendicitis.[3] This study is based upon the bacteriological examination of eleven cases of exudative appendicitis, which he has personally investigated, and of sixteen cases reported by others. Of these twenty-seven cases, in which a careful bacteriological examination of the exudate was made, in twenty-five the *bacterium commune coli* was the only species of bacteria found. In one of his cases, associated with the *bacterium commune coli*, a few colonies of streptococcus pyogenes developed on the agar plates. In a single case, reported by Welch, the streptococcus pyogenes was the only bacterium contained in the exudate.

Hodenpyl regards this germ to have been the cause of the lesions in twenty-five of these twenty-seven cases, and brings forward very conclusive evidence in support of this opinion. He obtained on cultivation from the contents of twenty appendices (both normal and pathological), pure cultures of the *bacterium commune coli* in nineteen cases. In one case colonies of streptococcus pyogenes were also discovered. It appears that the interior of the appendix in still-born children is sterile.

[1] Annals of Surgery, September, 1893.

[2] Bacterium Coli Commune, en orsak till Appendicit, Upsula Läkere. Förh., 1892–3, XVIII, 113–150.

[3] Dr. Hodenpyl has very kindly placed the results of his observations at my disposal. His article, containing an account of his investigation, is still in press.

He finds upon investigation (ten cases) that no bacteria of any kind are present in the healthy peritoneal cavity.

Regarding the pathogenic power of *bacterium commune coli*, he gives strong, positive evidence, which he divides under two heads: (*a*) The fact that it has been found in a great variety of lesions elsewhere unassociated with any other germ; and (*b*) the positive results of experiments on animals with pure cultures of the germ.

It is his belief that while this germ in the intestinal canal under normal conditions is entirely inert, when it escapes into tissues where it does not naturally belong, or when the natural conditions become altered, it may assume pathogenic characters, differing in the different cases.

While in exceptional cases exudative appendicitis may be caused by various species of bacteria, it is caused in the majority of cases by the escape into and through the walls of the appendix of the *bacterium commune coli*, which this organ constantly harbors in its lumen.

As predisposing causes to the disease may be mentioned actinomyces and tubercular and typhoid ulcers. The influence of fæcal concretions has already been referred to. Actino mycotic appendicitis has been observed by Ransom[1] and by Otto Lanz.[2] The occurrence of occlusions of the lumen, either partial or complete, are likewise predisposing factors. According to Hodenpyl, these occlusions may be the result of former inflammatory changes, but are more frequently the result of retrograde evolution which this organ seems to be gradually undergoing.

The invasion of the mucous membrane, and of the submucous layer of connective tissue as well, by micro-organisms which are possibly harmless so far as the mucous membrane of the colon is concerned, but are disease-produciug in the mucous membrane of the appendix, at all events, will account for all of the phenomena of the disease. The normal epithelial lining of an organ, useless in the animal economy, and which is probably undergoing evolutionary changes tending towards its final dis-

[1] Proceedings of the Royal Med. Chir. Soc., London, 1891–2, S. IV, 14.

[2] Korrespondenzblatt für Schweitzer Aerzte, 1892, No. 19.

appearance, may be found by the histologist to have already been subjected to changes which distinguish it from that lining the cæcum, and which may have robbed it of its function as a barrier to bacterial infection. Among these evolutionary changes a progressively lowered vital resistance would naturally be the first departure, so far as the tissues are concerned, and this alone would favor violent inflammatory alterations, though the same etiological factors would not be sufficient to produce these effects in the colon or ileo-cæcal region. It has been suggested that the difference in the lumen of the cæcum and appendix may account, to some extent, for the immunity of the cæcum and the susceptibility of the appendix. It is easier to produce abrasions in a small tube than in a large one, and the mucosa once deprived of its epithelium easily becomes infected by micro-organisms.

The conclusion is, therefore, irresistible that infection is not only the principal and necessary cause of the appendicitis, but that it is also the primary cause. Some infectious material enters the appendix, and there becomes fixed as a result of the very inefficient expulsive power of the organ. The secretions of the appendix furnish excellent soil for the development of the micro-organisms. The degree of virulence of these organisms will govern the violence of the inflammatory catarrhal attack if other conditions, such as the existence of stenosis of the canal, or the presence of concretions, are favorable. The ease with which the disease may become chronic is due to the fact that the tissues of the organ are being continuously fed by constantly proliferating infectious material and its toxic products. With any increase of virulence there occurs a renewed or acute attack. Whatever fæcal matter, either fluid or solid, chances to be present plays but an accidental rôle. It is not even necessary that these fæcal masses should produce either ulceration or even abrasion of the mucous membrane. As a matter of fact, their physical qualities are usually such as render it altogether probable that they produce no primary lesion, but that in their soft condition they may remain for an indefinite period of time within the tube without doing harm. That fæcal masses do occur within the

cavity of the appendix vermiformis without the occurrence of inflammatory processes is proven by the frequency with which their presence is noted in post-mortem examinations, as well as in laparotomies performed for other conditions.

The *bacterium commune coli* is the bacterium found in the intestinal canal with the greatest frequency. It has already been shown (*vide supra*) that under certain conditions this is a pathogenetic micro-organism, hence when it is found in pure cultures in cases of appendicitis it may with reasonable certainty be looked upon as the cause of the disease.

The pyogenic staphylococcus and streptococcus may also be present in the pus and in the sero-purulent fluid found in appendicitis, if these have been taken in with the food, and have escaped the action of the digestive fluids. This is probably of rare occurrence. Dr. E. H. Wilson, pathologist to St. Mary's Hospital, found in a specimen of fluid from an encysted intra-peritoneal focus taken from one of my appendicitis cases, and within the cavity of the appendix taken from another case, the *bacillus pyogenes fetidus* in addition to the *bacterium commune coli*. Bouillon cultures of the *bacillus pyogenes fetidus*, derived from the latter source, injected into the peritoneal cavity of a guinea pig, produced death within twelve hours from a profound toxæmia. This organism was recovered from the exudate in the peritoneal cavity of the animal.

The relation of the blood supply to the occurrence of the disease has led to a critical study and review of the conditions which govern this supply. These studies have been principally directed to the presence or absence of a mesentery connected with the organ. So far as I have been able to judge, from the examinations made of appendices removed in a diseased condition, the disease occurs quite as often in those individuals in whom a well-formed and vascular meso-appendix is present as in those in whom the mesenteric attachment is but slightly developed or altogether absent.

The study of the clinical anatomy has not, to my knowledge, been heretofore undertaken. The shape and relative position of the appendix as found in individual cases may favor

the development of the disease. Thus, an angulated or exaggerated curve-shaped appendix may favor circulatory disturbances, and a directly vertical position with the tip downwards the engagement in the orifice of hardened fæcal matter, which, acting as a local irritant, leads to the development of the disease. The absence of anything like uniformity in its relation and direction under conditions of both health and disease, however, rather tends against the relation of the above-mentioned conditions as ætiological factors except in a casual or predisposing manner. While, therefore, these will explain the occurrence of certain symptoms in some cases which are absent in others, they cannot be looked upon as essentially ætiological factors in the disease.

The condition of the bowels prior to the attack has been the subject of considerable study in connection with the disease. The only conclusion which can be drawn is that neither preceding constipation nor diarrhœa occurs in a sufficiently large number of cases to stand in a causative relation to the disease; and that a normal condition of a daily movement of the bowels is observed in the majority of cases.

The influence of age upon the occurrence of the disease is of importance. The affection is not confined, by any means, to the age of childhood as was formally supposed; yet its somewhat greater relative frequency in early life has led to the opinion that age is one of the predisposing causes. It is rare at the two extremes of life. The comparative frequency, in my experience, of the diseases at the different periods of life, agrees essentially with the observations of Bamberger, Paulier and Maurin, as given by Talamon, and of Reginald Fitz, to whom the profession is greatly indebted for a large number of accurate observations upon the disease.

The influence of sex upon the occurrence of the disease has been studied by Bamberger (1864), Volz, Marchal, Paulier (1875), Fitz (1886 and 1888), and Maurin (1891). Taking the total number of cases of these observers, and combining them, the following result is obtained:

Total number of cases observed	557
Total number occurring in males	430
Total number occurring in females	113
Percentage occurring in males	80
Percentage occurring in females	20

In my own experience, about the same proportion of males to females was observed.

Among the occasional causes laid down by writers, traumatism is mentioned. In my experience, not a single instance occurred in which a kick or a blow upon the abdomen or a fall constituted a portion of the history. The nearest approach to this is the case of an ice-man, who attributed the attack to a strain he had received the day before in lifting a heavy block of ice from his wagon. Another instance is that of an athlete in whom the disease developed during the night after he had engaged in a game of football. In neither of these cases does it seem to me that the violent effort or exercise bore any causative relation to the attack of appendicitis.

Indigestion has also been regarded as one of the determining causes of the attack. This belief has probably arisen from the frequency with which vomiting and pain, referable to the epigastrium, are prominent symptoms of the first stage of the attack. These symptoms, as has already been insisted upon, are not due to digestive disturbances, as a rule, but are purely reflex phenomena. It rarely happens that undigested food is vomited, and the movements of the bowels following upon an attack of appendicitis do not show evidences of irritating ingesta. It is common enough to have patients declare that they must have eaten something which disagreed with them, but so far as my experience goes I have failed to trace an ætiological relation to such a cause even by careful questioning, save in but a single instance (*vide infra*). Talamon, however, believes that the erratic peristalsis produced by the presence of irritating material alone within the digestive tract determines the engagement of a stercoral calculus in the orifice of the appendix. This in its turn gives rise, according to this observer, to the symptoms here described as constituting the first stage of the disease.

In the rare instances in which the digestive disturbance seems to precede the development of the disease, the connection between the two occurrences may still be dependent upon bacterial agency. It has been shown by experiments upon animals that cultures of the *bacterium commune coli* derived from patients the subjects of diarrhœal diseases possess far more virulent toxic properties than those taken from healthy individuals.[1] Whether the catarrhal inflammatory conditions present in these diseases, and which, to a greater or lesser extent, are present in those attacks commonly regarded as the result of indigestion, and the increased virulency is due to the irritating ingesta which produced the indigestion, or whether, in the life-history of the bacterium, the virulence occurs as a part of the biological changes which it undergoes, this, in its turn, acting as the irritating or infectious agent, has not as yet been determined. If the former it may readily be supposed that an attack of indigestion, by producing certain changes in the intestinal tract and converting the theretofore harmless micro-organism into one of greater or lesser virulency, would stand in a causative relation to the disease. In this connection the following case will be of interest:

CASE XXIX. M. B., aged forty-seven, with no history of a previous attack, and of previous regular habit of bowels, dined at a cheap restaurant, which was not at all his habit, making a hearty meal of pork and cabbage. He was attacked the same evening (December 15, 1889) by pains, referred to the epigastrium, with vomiting. Pain in the right iliac region developed four hours later and tenderness in the latter region was present upon the following day. The vomited material consisted of the partially digested food of the above mentioned meal. I saw him on the fifth day, at which time a tumor was present. An incision made into the latter, evacuated about five ounces of sero-purulent material from a cavity formed by adhesions about the inflamed appendix. The latter lay in the N. E. position, and was evidently a portion of the limiting wall of the abscess cavity in that direction. For this reason the organ was not removed.

The patient made a good recovery, but on November 19, 1892, nearly three years later, he dined, under the same circumstances, at

[1] Macaigne, Le Bacterium Coli Commune, Paris, 1892.

the same restaurant, and partook of the same character of meal. The same evening he was attacked with pains and vomiting; the pain finally centered in the right iliac fossa. The vomited material showed partially digested pork and cabbage. Within thirty-six hours of the commencement of this attack primary perforation and septic peritonitis had taken place, shortly after which I saw him and operated. The appendix was removed and it was found to have been the seat of a rapidly suppurative process; extreme dilatation had taken place and rupture of its contents into the general peritoneal cavity followed. The patient was a diabetic, with low powers of vital resistance. It is interesting to note that the appendix, at the second operation, lay in the S. E. position.

In spite of the fact that the terms "typhlitis" and "perityphlitis" have been virtually abandoned, for the reason that, whatever the origin of the inflammation, the involvement of the appendix contributes most largely to the dangerous character of the affection, it is still thought by careful observers that the disease not infrequently has its starting point in a catarrhal inflammation of that portion of the cæcum corresponding to the point of communication between the latter and the appendix. Kümmel[1] still insists that the chronic relapsing form of appendicitis has it origin in inflammatory catarrhal processes within the cavity of the cæcum, being propagated thence by continuity of tissue to the interior of the appendix. The secretion of the latter continues to empty into the colon until the point of communication is closed by swelling near the orifice, or by stenosis elsewhere. This view is also held by Iversen, and is supported by the frequency with which strictures of the vermiform process are observed in the relapsing form of the disease. In this variety, too, perforation is the exception, and not the rule. While a mild inflammatory process at this part of the cæcum may pass away without the occurrence of symptoms sufficient to call attention to its presence, the occurrence of even a slight catarrhal inflammation of the appendix leads to constriction of the tube, the retention of secretion and to the formation of coproliths.

To sum up, therefore, the disease may be due, first, to infec-

[1] Archiv. für klinische Chirurgie, Vol. LIII, 3 and 4.

tion from the presence of the *bacterium commune coli* or some other micro-organism; second, to circulatory disturbances, more or less readily produced by sharply curved or angular shapes of the organ, or a deficient blood supply; third, to the presence of accidentally imprisoned fæcal matter, which is prevented from returning to the cæcum both because of the feeble expulsive power of the tube, due to an insufficiency or entire absence of circular muscular fibres, and on account of constriction of the tube which may or may not be due to previously existing inflammation. This fæcal matter, because of bacterial infection which it conveys to the parts, or from the pressure effects due to inspissation, or both, contributes to the ætiology of the disease in its entirety, but particularly in the cases in which perforation takes place. Bacterial infection, however, may occur independently of the presence of fæcal matter, and the presence of fæcal concretions is not at all essential to ulceration, perforation or gangrene.

Special Types of Appendicitis.

Special types or varieties of the disease are sometimes observed, differing from the affection as already described. Even in these cases, almost without exception, there can be obtained a history of the first, second and sometimes of the third stage of an average acute attack. From this point, however, the symptoms seem to veer off, as it were, from the typical course, only to return to it after a greater or lesser length of time.

The forms now to be considered are the subacute, the chronic, the relapsing and the recurrent varieties.

Subacute Appendicitis.—The *subacute* variety is not to be looked upon as an innocent form of the disease. Although the febrile action is slight, and the pain and tenderness such as occasion no alarm, these insidious symptoms may be replaced, without warning, by those indicating the occurrence of perforation, and suppurative or non-suppurative septic peritonitis; or the latter condition, as already stated in discussing the acute variety, may come on without perforation. The subacute form may supervene upon the acute variety. Convalescence may follow this remission of the symptoms, but the change from an acute

to a subacute form is only too often more apparent than real, and leads to a sense of fancied security on the part of the physician and patient, to be followed by the occurrence of one or more of the grave accidents which only too frequently mark the further progress of the disease. This was strikingly exemplified in the case of Gambetta, the celebrated French journalist.

Chronic Appendicitis.—Where the affection stops short at the first stage, or perhaps even recedes more or less from this to a stationary but persistent condition of subacute endoappendicitis, it is said to have assumed a chronic phase of the disease. The mucous membrane, and perhaps in addition, the submucous connective tissue, persists in a condition of subacute inflammation, from which one or more relapses may occur in the course of a few weeks. The patient may become seemingly convalescent, in that pain and all febrile symptoms disappear. He may even be permitted to resume his avocation. Within a few weeks, or even earlier, a relapse takes place, with symptoms perhaps more violent and threatening than at first. There is one symptom, at least, which does not entirely disappear, and its presence should always place the attendant upon his guard against this form of the affection. I allude to the symptom of persistent tenderness. This is sometimes accompanied by the presence of a tumor, although the latter is not an essential symptom of this type of the disease.

Cases are sometimes observed in which the symptoms are from the beginning indicative of a subacute condition.

Recurrent Appendicitis.—This form of the disease is not rare. A certain proportion of cases occurring in adults will give a history of previous attacks, one or even more in each year. These cases are to be distinguished from the chronic relapsing form, and it has therefore seemed best to assign them to a special class. The special feature of the form under consideration is the fact that the attacks occur at either short or long intervals, suggesting some predisposing cause, which continues active after recovery from the first attack. It differs from the relapsing form of the disease in that entire recovery takes place. The patient remains free from any trace of the affection for varying periods,

when suddenly and without warning he is subjected to another attack. The differences between the relapsing and the recurrent forms of the disease are analogous to the differences existing between an attack of typhoid fever in which a relapse and a second exacerbation supervenes during the convalescence, and an attack of malarial fever in which complete recovery takes place, but in which some predisposing condition residing in the patient conjoined with some exciting cause incident to his surroundings, leads to a recurrence of the disease.

The length of time over which these recurrent attacks may extend is surprising, as well as the remarkably large number which may occur within a short time, and yet recovery take place.

The following are presented as illustrative of this class of cases:

CASE LXXIX.[1]—J. N., aged forty-five, was seen by me in consultation with Dr. Weygandt, of this city, during an acute attack of appendicitis. He declared that he had suffered during the past eight years from attacks of colicky pain, referred to the general abdominal region, occurring at intervals varying from one to three months, and that he must have had more than fifty such attacks. An operation performed January 12, 1893, revealed an appendix which was thickened, strictured, dilated beyond the stricture, ulcerated and perforated at the dilated portion, angulated at the proximal portion of the organ, and gangrenous between the angulated portion and the base. The appendix was removed.

The patient made a good recovery, and when last seen, nearly a year after the operation, he stated that he had remained in perfect health ever since that time.

CASE CIV.—Dr. H. W. C. came under my care with the following history: Two years before, while traveling in California, he was attacked during the night by appendicitis. He had eaten a hearty meal before retiring. After a week he convalesced. During the succeeding two years he suffered from thirteen separate and distinct attacks. These were sometimes preceded by diarrhœa, and sometimes by constipation. On October 27, 1891, the appendix was removed after the subsidence of an attack. It was found to be the seat of a chronic thickening, its cavity being obliterated, and its structure changed to a fibrous cord.

[1] These numbers refer to my case-book records.

COMPLICATIONS AND SEQUELÆ OF APPENDICITIS.

The most important complication of appendicitis is the occurrence of peritonitis in one of its forms. Inflammation of the serous investment of the appendix itself is not included in the present consideration, nor should the occurrence of this form of localized peritonitis, which leads to the formation of adhesions, be considered other than salutary. Diffused inflammatory affections of the peritoneum resulting from infection, or septic peritonitis, which may or may not result in a suppurative process, are, however, among the most frequent, as well as the most fatal, complications.

Iliac Phlebitis.—This may occur as a complication of appendicitis. The condition will prove a very obstinate one to deal with. It is due to an infection, either from appendicular abscess, or a suppurative parietal appendicitis. In these cases the appendix lies in the direction W. or S. W. (Fig. 7). Phlebitis of both sides may occur simultaneously, due to an infection of both veins by a long appendix stretching across on the W. line; or the vein on the left side may become involved subsequently to that of the right.

Phlebitis with thrombosis of the iliac vein will give rise to œdema of the corresponding lower extremity. If septic changes occur in the thrombus, and portions of the clot become loosened and displaced, pulmonary thrombosis and septic pneumonia may be among the sequelæ of appendicitis.

Where the complication of iliac phlebitis and thrombosis occurs the convalescence will be considerable prolonged. These cases are usually tedious, and are not amenable to any specific treatment.

Fatal Hæmorrhage.—This may follow invasion of the iliac veins by the gangrenous process. The artery is much less liable to this accident. The following instance of the invasion of the right iliac vein came under my observation:

CASE XLIV.—H. W., male, aged fifty-seven. Patient was seen by me January 22, 1891, in consultation with his family physician, Dr. Cruikshank. The usual symptoms of an acute appendicitis had ac-

companied the outset of the attack. Upon the fifth day he had apparently entered upon a safe convalescence, when grave symptoms suddenly supervened. An immediate laparotomy was performed. A gangrenous appendix was found in the S. E. position, imbedded in a mass of adhesions which were also in a gangrenous condition. The wound cavity was thoroughly cleansed and drained and the patient's condition improved. On the eighth day, while the wound was undergoing its usual daily redressing, a gush of blood followed the withdrawal of the gauze drains. This was temporarily controlled by the finger passed to the bottom of the wound cavity, and a tampon arranged as a graduated compress was firmly placed in the cavity and controlled the hæmorrhage. He never rallied, however, from the loss of blood, and died upon the following day.

Complications arising through the Medium of the Portal Circulation.—When the freedom with which the mesenteric veins feed the portal circulation is taken into account, the ease with which septic emboli from thrombo-phlebitis of these radicles may be carried to the liver, and there give rise to hepatic abscess, will be readily understood. As a matter of fact, however, mesenteric thrombo-phlebitis is only an occasional complication of appendicitis. Reginald Fritz calls attention to the possibility of its occurrence, and suggests that it may be due, either to a direct extension of the primary phlebitis, or from septic embolism.[1] Three cases of hepatic abscess of appendicular origin, in which pleuritis and pericarditis followed an eruption of the abscess cavity through the diaphragm, are reported by Gendron.[2]

This, as well as other late complications and sequelæ of the disease, will become less and less frequent as the dangerous character of the disease becomes more generally recognized, and early operative procedures are instituted for its relief.

Hepatic Abscess—As a result of pylephlebitis, hepatic abscess, either single or multiple, may occur. This is a most serious complication, and may so mask the other symptoms as to completely mislead the attendant as to the true nature of the case. The thromboses within the mesenteric veins become dis-

[1] American Jour. Med. Sciences, October, 1886, page 330.

[2] Étude sur le pylephlebite suppurative, Thésis de Paris, 1885.

placed, either in their entirety, or by portions becoming loosened and are swept by the current of blood into the portal vein, through which channel they reach the liver in the shape of sepsis-bearing emboli. The mechanism is the same as in hepatic abscess following dysenteric affections and certain operative procedures upon the hæmorrhoidal veins.

The symptoms of hepatic abscess following appendicitis are such as accompany suppurative foci within the liver substance due to other causes. Digestive disturbances, irregular chills, pain referred to the right hypochondriac region, erratic variations of temperature, tenderness just beneath the lower border of the ribs upon the right side, more rarely an icteric hue of the conjunctiva and skin, finally the occurrence of a tumor—these are the symptoms which change almost entirely the aspect of the case, and render the symptomatology puzzling to the medical attendant, unless he is mindful of the occurrence of this complication.

Purulent Pleuritis or Purulent Pericarditis.—These may result from the hepatic abscess. A large collection of pus, situated superiorly or posteriorly within the liver, will tend to find its way through the diaphragm. The latter will first be pushed upward, and give rise to difficulty of breathing. Later on the diaphragm itself will become inflamed, giving rise to considerable pain, and finally, ulceration and perforation will permit the pus to find its way into the pleural cavity, or into the cavity of the pericardium. If it be not removed from this situation by operation, and the patient survive sufficiently long, the purulent collection may ultimately be discharged externally either by means of a spontaneous opening between the ribs, or through the bronchi. Especial attention has been called to suppurative pleuritis as being a relatively frequent complication of appendicitis by Terrillon.[1]

Pelvic Phlegmon.—An exceptionally long appendix, placed in the S. E. position, may lead to an infection of the tissues

[1] Discussion upon Quenu's paper, "Operative Treatment of Recurrent Appendicitis in the Intervals of the Attack." Bull. et Mem. de la Soc. de Chirurgie de Paris, Vol. XVIII, p. 397.

within the pelvis, the results of which may not be apparent until a considerable time has elapsed after the beginning of the disease, or after the operative procedure instituted for the removal of the diseased appendix. The following case is of exceptional interest in this connection.

CASE CVIII.—M. E. S., female, aged twenty-one, was admitted to the Methodist Episcopal Hospital, May 14, 1893, suffering from a rapidly developing attack of appendicitis. No previous attack had occurred. The abdomen was opened by the usual right-sided vertical incision, and the appendix, which was ulcerated and perforated, was removed. Its position was southeast, or directly downward and inward, across the vessels, and its length was five inches. The colon was placed abnormally low, and the appendix reached well down and into the pelvis and seemed to lie between the rectum and the uterus. The appendix was removed. The depths of the infected area were cleansed as thoroughly as possible, and a drain of iodoform gauze placed in position. The external abdominal wound was only partially closed. The patient was discharged from the hospital after a six weeks' convalescence with the wound entirely healed.

On October 2, 1893, nearly five months after the operation, she was again admitted to the hospital, with a history of having suffered from what was thought to be malarial fever. An examination disclosed a fluctuating tumor, situated between the uterus and the rectum, which filled the entire cul-de-sac of Douglas. A second laparotomy was performed. The tumor was found to be a large abscess, located behind the uterus. The rectum was nearly perforated by the abscess. Both tubes and ovaries were normal.

Lumbar Phlegmon.—This may have its origin in infectious processes, invading the post-peritoneal connective tissue. An antecedent history of appendicitis may usually be made out, culminating in the discharge of pus into the structure of the lumbar region. In two cases of this kind, occurring in my hospital service, one died from purulent infection of the lumbar and dorsal regions, and prolonged septic conditions. The autopsy revealed a small post-cæcal abscess cavity, in the wall of which the thickened and infiltrated appendix lay. In the other case, upon incising the abscess wall, a large amount of pus, which had been

walled in, escaped. Upon introducing the finger a communication was found to exist between this one and a similar smaller cavity lying behind the cæcum.

There is a growing belief among surgeons that the dorso-lumbar abscesses of former times which could not be ascribed to a lesion of the osseous spinal column, and which were sometimes called peri-nephritic abscesses for want of a better notion regarding their origin, were really cases of suppurative inflammation of the retro-peritoneal connective tissue, having their origin in an appendicular abscess, in instances in which the appendix lay entirely or in part behind the peritoneum. Even a history of an acute attack of appendicitis may be absent in these cases, and yet the infection have its origin in the appendix.

Parietal Phlegmon.—Abscess of the anterior abdominal wall is comparatively rare. A case of this kind came under my notice at St. Mary's Hospital. The history dated back several weeks, and involved the usual and typical symptoms of appendicitis. Two other cases were seen in consultation. The patients were both children. The primary attack in the one case occurred two months, and in the other case three months previously. The abscess in both cases pointed at the umbilicus.

The Occurrence of Appendicitis in a Hernial Sac.—This should be noted as among the complications occasionally met with. At a meeting of the Brooklyn Surgical Society,[1] Dr. Rand presented a case in which an old and irreducible femoral hernia became the seat of a phlegmonous inflammation. The usual symptoms of appendicitis preceded the local appearances. An incision revealed the existence of an inflamed appendix, with an encysted seropurulent collection.

Fæcal or Urinary Communication.—These conditions resulting from a spontaneous evacuation of a purulent or sero-purulent collection into the rectum or bladder, giving rise to renewed infection from these sources, have already been referred to as a complication.

Appendicitis Complicating Pregnancy.—This complication is

[1] March 16, 1893.

of occasional occurrence. Four instances have come under my observation in a series of 143 cases. All four developed septic peritonitis before coming under observation. In two abortion took place prior to operation, while in the others the uterus emptied itself after the operation. All four died, the abortions not necessarily hastening, but rather heralding the fatal issue.

Talamon[1] mentions a case observed by Oppenheimer, in which the patient, at the seventh month of pregnancy, was attacked with the usual symptoms of appendicitis. Premature delivery took place on the third day, resulting in death. At the autopsy a post-cæcal para-appendicitis, and a perforated appendix were found, with pus burrowing along the kidney, and into the post-peritoneal connective tissue. Metastatic abscesses in both liver and spleen were likewise observed.

Appendicitis Complicating the Puerperal State.—One case of this kind was sent to my hospital service by Dr. F. E. Wilson, of this city. The case recovered after laparotomy. In all probability there was no especial relation existing between either the parturient act or the puerperal state and the etiology of the disease, inasmuch as the attack occurred ten days after the delivery. Attention is called to the case from the fact that when appendicitis occurs in the pregnant condition, as far as my experience goes, it is invariably followed by abortion with a fatal result; but in the post-parturient condition at term it does not seem to be such a mortal affection.

[1] Op. cit.

[TO BE CONTINUED.]